INDEX.

REPORT ON IRRIGATION ON THE SIROHI STATE.

Geographical Features.

1. The Sirohi State is bounded on the north and west by Marwar (Jodhpur), on the south by Palanpur and the Mahikantha State of Idar and on the east by Mewar.

2. It has an area of 3,020 square miles; its greatest length from north-east to south-west is 62 miles, and its greatest breadth from south-east to north-west is 46 miles.

3. The country is intersected with hills and rivers and nullahs. The Joai River forms the northern boundary of the State, but, except for two miles of its length near the north-east corner of the State, belongs to Marwar.

The Aravellis form the east border of the State; and Mount Abu, the highest and most important of these hills, is at the extremity of a parallel range which divides the State into two portions. In this range, about 26 miles from the north end of Mount Abu, is the town of Sirohi.

Drainage Areas.

4. The eastern portion is the drainage area (No. 7 Index Map) of the principal river in the State, the Western Banas, which rises in the hills behind the town of Sirohi and flows in a south-west direction through the valley between the Aravellis and the Abu Hill. After leaving the Sirohi State this river enters Palanpur territory, and eventually loses itself in the sand at the head of the Rann of Katch.

5. In the western portion there are six drainage areas of the following rivers and nullahs:—

(1) Sukri.

(2) Khari.

(3) Krishmauti, with its tributary the Khemeri.

(4) Kachmauli Nullah.

(5) Kopalgunga Nullah.

These all rise in the Sirohi range of hills, and flow in a north-western direction, and eventually join the Luni River.

(6) Sukli River.

The two branches of this river rise in the high ridge which runs across from east to west in the western portion of the State just north of Abu; they flow in a south-westerly direction, and eventually join about six miles within the south border of the State; after their junction the river flows into the Western Banas, just above the Cantonment of Deesa.

6. With the exception of the Sukli (No. 6) water only flows in these rivers and nullahs in the western portion for a few days or hours

during the rainy season, depending on the rainfall. For the remainder of the year they are quite dry. The Sukli has water in it in pools all the year round, and in the western branch water generally flows throughout the year.

Area.

7. The following are the areas of cultivated and uncultivated land and the proportion of each which is Khalsa :—

	Area Cultivated.	Area Uncultivated.	Total.
	Acres.	Acres.	Acres.
	2,22,857	10,34,103	12,56,960
Khalsa ...	78,873	3,65,989	4,44,862

Of the cultivated area about 30,000 acres (75,000 bighas) are irrigated and produce Rabi crops, the remaining 1,92,857 acres being only cultivated in the rains.

Only about $\frac{1}{5}$th of the whole State is therefore under cultivation.

Population.

8. The population of the State according to the Census of 1891 was 1,90,836, of which 33,154 were Bhils, Grassias and Minas. In the last Census the figures were 1,54,544, of which 18,126 were Bhils.

The decrease of 36,292 is due to the last famine, and cholera and fever which followed.

Villages.

9. There are 413 towns and villages in the State, of which 145 are Khalsa and 268 belong to Jagirs and Charitable Institutions.

In the Jagir villages, however, the Durbar receives a share varying from $\frac{1}{4}$ to $\frac{3}{4}$ of the whole produce.

Land Revenue.

10. The average Land Revenue is—

From Khalsa villages	Rs.	89,000
„ Jagir villages and Charitable Institutions	„	3,15,000
Total	Rs.	4,04,000

Of this Rs. 1,83,300 are realised from Kharif and Rs. 2,20,700 from the Rabi crop.

11. There are three systems of Revenue collection in force—

(1) For some land a fixed quantity of grain per bigha is levied, which is not affected or modified according to the gross produce.

(2) For others a fixed share of the gross produce is realised.

(3) For certain land a fixed money assessment per bigha is realised.

12. The average rainfall, excluding Mount Abu, is 23·67 inches. Rainfall.

13. All the irrigation in the State is at present carried out from wells, and there are 5,180. Means of Irrigation Wells.

The average depth of water below the surface of a number of wells measured is 35 ft.; and the cost of a well varies from Rs. 300 to Rs. 800.

14. The area irrigated by wells is approximately 75,000 bighas, which gives an average of nearly 14½ bighas per well. An average well can irrigate four bighas in 12 hours, and the average cost of one watering per bigha is 8 annas.

The average revenue derived from well irrigation is Rs. 1,84,000 per annum.

In the famine year 40,000 bighas of land were irrigated from wells, and a revenue of Rs. 50,000 derived.

15. It will be seen that the villages are nearly all situated on the banks of the many nullahs which cover the State, and the wells are similarly situated, and in consequence very seldom run dry; though I noticed a good number which were not being brought into use this year, some as the owners had died in the famine and there was no one to take over the well and land; others because the owners' supply of bullocks was deficient, and a very few as the wells had not sufficient water. But although the State is hilly and covered with nullahs, as this Report will show, the sites for really good Irrigation Tank projects are limited; whereas it is particularly well adapted for well irrigation, as, owing to these numerous nullahs, water is fairly close to the surface, while the country itself is broken up, with a limited area of culturable land scattered about.

16. I would strongly recommend the State, as a protective measure, giving assistance to deepen all those wells in which the water is insufficient, and wherever more land can be taken up and there is a demand for sinking fresh wells, to advance funds for this work.

17. In the last famine a great portion of the crops produced by irrigation from wells was used in preserving the agricultural cattle, and the actual production was greater than the revenue realised. Wells have this advantage that they are also not absolutely dependent on the rainfall but from natural springs, and they are comparatively cheap to construct; 25 large wells could be constructed for Rs. 20,000, and this would only be sufficient for a small Storage Tank, which would probably be dry in a famine year.

18. Although there are a number of small village tanks used for watering the cattle, there are at present only two tanks which have been constructed for irrigation:— Tanks

(1) Chandela at the foot of the Abu Hill (Site No. 23 Index Map) and eight miles from Abu Road. This was an old tank, enlarged and improved in the last famine. Rs. 24,765 have been spent on the work, of which 16,000 was on account Chandela Tank.

of famine labour. The tank has only a small catchment area of $\frac{3}{8}$ square mile of its own, but is supplied by diverting a portion of the water of the Gomti River, which flows down from the Abu Hill, and across which a weir has been built and a feeder constructed. The tank is capable of irrigating 675 acres.

Pindwara Tank.

(2) Pindwara Tank (Site No. 16) constructed in honour of the Diamond Jubilee of the late Queen-Empress Victoria.

The work was designed and carried out by the Ex. Engineer, Mount Abu, at a cost of Rs. 39,504. It has a hilly catchment area of 7 square miles, and the capacity of the tank is 56 m. c.ft., sufficient for 560 acres. The tank fills easily each year, but unfortunately it leaks extensively through the hill between the two dams, which consists of stratified rock, and in consequence the tank is empty by December. This is most unfortunate, but could not, it is thought, have been foreseen. There is no possibility of stopping this, though, perhaps after some years, owing to deposits of silt, it may lessen. In the meanwhile all that can be done is to have low earthen bunds prepared across the land commanded to hold up water, and directly the tank fills, to let off the water to inundate this land, which can be cultivated later with wheat or barley.

The sub-soil of Sirohi appears, as a rule, unsuitable for the artificial storage of water, as even in the village tanks it was noticed that the water subsides very rapidly after the rains.

(See Note by Consulting Engineer for Irrigation—Appendix A.)

Sirohi Tank.

19. In addition to these two tanks, during the famine, work was carried out :—

(*a*) On the construction of a new tank at Sirohi, with a feeder from the Baldah Nullah (Sites Nos. 3 and 4), on which Rs. 47,000 was altogether spent, and Rs. 10,250 have since been expended, and the work is still incomplete. This is noted on in para. 36 below.

(*b*) At Bhula, near Rohera (Site No. 19), Rs. 14,900 was spent in digging foundations for the dam of a tank, and breaking up ballast for concrete for same. This work is also incomplete. (See para. 57 below.)

Other forms of Irrigation.

20. In addition to irrigation by wells, where hill streams exist, a katcha bund is erected across the stream after the rains, and water is taken by a "saran" to irrigate the fields; and the total area in the State so irrigated is estimated at 15,000 bighas.

Field Bunds.

21. Down in the north-west portion of the State, by Manadar, the water from the nullahs from the hills on either side flows down in the

rains and spreads over the valley, where it is held up by "pals," *i.e.*, field embankments, and later in the season gram and barley are sown. In years of good rainfall 5,000 bighas are estimated as brought under cultivation in the whole State in this way.

Reserve of grass.

22. In my tour in the State it was noticed that apparently there was no reserve stock of grass stored in any of the villages. Considering the quantity of grass-land all over the State, and that the people so largely depend on their cattle, both for agricultural work and dairy produce, for which latter purpose large herds of cattle are kept in most of the villages, and that the loss of cattle during the last famine, estimated at four lakhs of rupees was due, not to want of water but to want of fodder, it seems most important that the Durbar should insist and see that a year's reserve stock of grass is kept in every village.

Drainage Areas noted on.

23. Each drainage area will now be taken, and the irrigation works considered possible and suggested in each noted on.

Sukri River.

24. SUKRI RIVER (Drainage Area No. 1).—The Sukri River rises in the Aravellis in Marwar, through which State it flows for about 9 miles before entering Sirohi. The river has a total length of 29 miles, and flows in a north-western direction, joining the Joni River at the north-west corner of the Sirohi State. With its tributaries it drains an area of about 211 square miles.

Khirdaria Nullah.

25. The Khirdaria Nullah, which has a catchment area of 22 square miles, has been included in this drainage area, though the nullah never actually joins the Sukri, as the flood water in the rains spreads over the surface of the country, just below the village of Khirdaria, and flows away and benefits some grass-land in the Marwar State.

Nothing can be done here, and the villages of Khirdaria, and Vera also get the benefit of this surface water, and good rain crops are grown on the land thus inundated.

Rarbor Project.

26. On the Sukri River itself surveys were made for a Storage Reservior at Rarbor (Site No. 1, see Map of State), where the river flows through the hills, and has a catchment area of 98 square miles. The dam would be 4,000 r. ft. in length, and with weir level at 30 feet above bed of river, about 563 m. c. ft. of water can be impounded; which is equivalent to a run-off of a little over 10% of the average rainfall of 23½" from the catchment area, which is all hilly. The weir, which will be 675 r. ft. in length to pass the maximum discharge on the catchment area with a 5 feet head, would be at the west end; and the dam would consist of an earthen embankment with core-wall 11½ feet wide at top and 8 feet above weir level; front slope 3 to 1 pitched, and rear slope 2 to 1. The core-wall would be of masonry taken up to top of dam 1½' wide at top and 3" offsets on either side at every 5 feet depth; the foundations will be of concrete taken down to hard soil, or to a depth equal to half the height of water against the dam, as from trial pits dug no rock is obtainable. There will be sufficient water to irrigate 5,500

acres, and there is plenty of land below, and allowing Rs. 4 per acre as revenue, Rs. 22,000 per annum should eventually be realised, or a profit of nearly 8°/. on the approximate estimated cost of Rs. 2,79,000.

Chuli Project.

27. But the site is really not a good one, the basin being V shaped, necessitating a long bund at the broad end; and owing to the uncertainty of foundations, leakage will probably occur; and I now consider it would be better to construct a weir across the river just below Rarbor and opposite Chuli, where it leaves the hills, and divert the flood water down a canal on the left bank to inundate the land lying uncultivated belonging to the villages of Utan, Atwaro, and Pachalia. A low earthen bund was, I am informed, constructed many years ago at this point across the river, but it was breached and washed away by the first flood; but the commencement of a canal still exists. Earthen bunds would have to be constructed across the land commanded to hold up the water diverted and to inundate the land, and when the higher land was sufficiently inundated the water would be let down to the next bund, and so on. All these bunds need not be constructed at once, but the system could be increased as the project proved successful. This would be a cheaper arrangement than a storage reservoir, and the same quantity of water would still be made use of.

28. The Consulting Engineer inspected the sites both for the storage reservoir above Rarbor, and for the weir at Chuli, and agrees with me that the latter proposal is the one to adopt.

(See Note by Consulting Engineer for Irrigation—Appendix B.)

Consulting Engineer's Instructions for Chuli Project.

29. In accordance with his advice and instructions the weir would start from the left bank, and be 800 ft. in length, the top of weir being 5 ft. above bed of proposed canal, which would be 2 ft. above the river bed. The weir would consist of a wall of masonry in lime, to form a backbone, starting with foundations about 6 ft. below bed of nullah, built, if nothing better is found, on the sand itself. This wall would be built up to the crest of weir and be 3 ft. thick at top. The front slope of the weir would consist of boulders thrown up with a slope of 3 to 1, and the rear slope would be of the same materials, only with a slope of 12 to 1; and at the toe a wall consisting of cube blocks of concrete formed at site, each weighing say half a ton in weight, would be embedded in the bed of the nullah to prevent any chance of the rear slope shifting, and scouring taking place.

On the right bank in continuation of the weir an earthen dam would be built, with crest 10 ft. above weir level, so that there will be no chance of water topping the same, and this dam will also prevent any chance of danger to the village of Chuli just below. The canal would be made 50 ft. wide, and taken out on to the surface with a fall of 3 ft. per mile; and the first storage reservoir would be constructed below, where levels permit about 7 ft. of water to be held up, the earthen bank being 10 ft. in height.

There are miles of good culturable land which can be brought gradually under cultivation in this way, and surveys for the project, as now

proposed, will be made, and an estimate prepared for constructing the weir, canal, and first storage embankment.

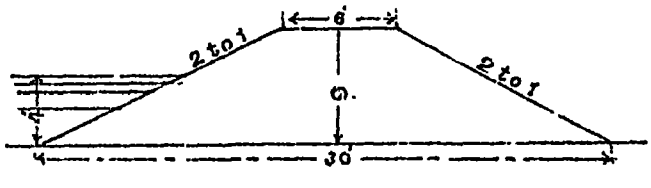
Weirs, with cuts, to supply Field Embankments.

30. This is a large river, and the cost in this case will consequently be heavy, but as all the nullahs run every rains for a short time, and the water at present passes away down them and is lost to the State, some cheap arrangement for making use of this water is required, and this method of weirs and cuts from the nullahs to fill existing tanks, or to inundate land where field embankments would be constructed, was recommended by the Consulting Engineer as most suitable both for the conditions and resources of the State. The slope of the country follows that of the nullahs, plenty of good land is lying waste, and nearly all this can probably be commanded by cuts from these nullahs. As the population is scanty the system should be started on a small scale to begin with and given a trial; good culturable land, which is at present lying idle, should be selected near a village for choice, so that cultivators are available.

Levels should then be taken to see how far back on the nearest nullah the cut should be made to command this selected land, and the approximate cost could then be easily estimated, and from this it could be seen whether the work was worth taking up or not. If it is, then permanent bench marks should be at once put in, and the projects if not at once taken up be placed on record, so that they could be taken up at any time.

Rock crossings on the smaller nullahs are frequent, on which a weir could be cheaply constructed, and the cut itself should be made broad enough to take all the flood water if possible. The field embankment would be made across the land at a point sufficiently below where the cut reaches the surface to allow from 3 to 5 ft. of water to be held up.

These banks would have an average section of:—



Area

and the average cost per mile = 5,280 r.ft. × 108 = 570,240 c.ft. at Rs. 4 per ‰ = Rs. 2,280. With cut and weir Rs. 3,500 would probably suffice to inundate ½ square mile, or 320 acres, or 800 bighas.

Suitability of this Proposal for Famine Relief Work.

31. The construction of these field embankments is just the form of work cultivators are accustomed to, and they would be most suitable for Famine Relief Works; the works would be distributed all over the State; the workers would not have to leave their homes, and would feel that they were benefiting themselves and their own villages in the future. The work could be done by petty contract and on measurement, so that the

State would only pay for what was actually constructed; and would eventually itself receive the benefit by increase of revenue on the extra land thus taken up. The estimating and setting out is simple work, and only requires levels being taken, and could easily be carried out by the State Overseer. This proposal should be carefully considered by the Durbar, suitable sites being selected in advance, and the lines for cuts and field embankments marked out. Holding up water in the nullahs will no doubt benefit the wells in the nullahs below, many wells being on the banks of the nullahs.

Khari River.

32. **KHARI RIVER** (Drainage Area No. 2).—The many nullahs which form this river rise on the western slopes of the hills north of Sirohi, and eventually join about 7 miles from their source at Ora village, where the Khari flows between two hills. From this point it continues its course in a north-western direction for another 8 miles, where it is joined on the left bank by the Krishmauti River, and passes into Marwar territory, eventually after another 28 miles flowing into the Luni. It drains a total area of about 130 square miles in the Sirohi State.

Ora Project.

33. At Ora there is an excellent site (Site No. 2) for a Storage Reservoir, which has been inspected and approved by the Consulting Engineer, and surveys are now being carried out, and the project will be worked out in detail.

The basin is good, no cultivated land will be submerged, and there is plenty of good land for irrigation below.

The tank will have a catchment area of 80 square miles, and allowing 10 per cent. of the average rainfall, 23½", as available for storage. should have a capacity of 437 m.c.ft., sufficient to irrigate 4,300 acres.

(See Note by the Consulting Engineer for Irrigation—Appendix C).

Krishmauti River.

34. **KHRISHMAUTI RIVER** (Drainage Area No. 3).—The Krishmauti, with its tributaries the Khemeri and Pardi Nullah, rises in the hills behind and to the south of the town of Sirohi, the Khemeri after a north-western course of about 15 miles, joining the Krishmauti on the left bank about 8 miles below Sirohi.

Two miles lower down the Krishmauti is joined, also on the left bank, by the large Pardi Nullah, and eventually after another 12 miles flows into the Khari on the border dividing Sirohi and Marwar. The Krishmauti and its tributaries drain an area of 196 square miles.

Naki Lao and Kalka Mata Tanks at Sirohi.

35. At the head of the north branch of the Krishmauti the two existing tanks of the Sirohi city, called the Naki Lao and Kalka Mátá (Site No. 3) have been constructed. These are not used for irrigation, and have small catchment areas.

36. During the famine the Sirohi Durbar started the construction of a new tank (see para. 19 above) by constructing a dam 2,500 r. ft.

in length, connecting the Kalka Mata Tank with a hill on the north to form one large lake. The work is incomplete, and has been stopped for the present.

Catchment Area and Baldah Nullah Diversion.

37. The Kalka Mata Tank has a catchment of $1\frac{1}{2}$ square miles, and the new tank which dams the Brujh Nullah, of $2\frac{1}{4}$ square miles. It was also proposed to enlarge the catchment area by diverting the Baldah Nullah (Site No. 4), which flows about 3 miles from Sirohi, from west to east towards the Western Banas, on the plateau above the town. A dam will have to be constructed across the Baldah Nullah and a cut made to carry the water back into the catchment area of the new tank. The cut was commenced as a Famine work, but is incomplete. By this means an extra 4 square miles of catchment area will be obtained, or $7\frac{1}{2}$ square miles will be the total catchment area.

38. I saw the Sirohi Tank work first in 1901, and found that the plans and estimates had never been worked out in detail, and that Rs. 47,000 had already been spent on it as a Famine work, and Rs. 10,250 later as an ordinary work. I advised H. H. the Maharao to stop the work, pending plans and estimates, which I prepared.

Estimate of Cost.

39. To carry out the work as originally intended and partly constructed, *viz.*, with a face wall and earth embankment behind, the total cost is Rs. 1,00,763, and at these estimated rates the value of the work done to date only comes to Rs. 14,522, so that Rs. 86,241 will still be required to complete it. This is exclusive of the Baldah Nullah diversion.

Capacity.

40. The capacity of the new tank as designed is :—

	m c.ft.
Capacity of Kalka Mata	13
Capacity of New Tank	20
Total ...	33

And in years of normal rainfall the tank should fill from its own catchment area of $3\frac{3}{4}$ square miles, but even if all the water stored was used, only 330 acres could be irrigated, giving a revenue of Rs. 1,320 at Rs. 4 per acre, or $1\frac{1}{4}\%$ profit on the estimated cost of Rs. 1,00,763, and this it must be remembered is exclusive of the Rs. 42,728 excess expenditure on work executed up to date.

41. The work should not be treated as an Irrigation work, but purely as an addition to the water supply to the city, and this is badly needed. As so much has been expended, it should be finished off in the cheapest way possible and I recommend filling in the foundations excavated with concrete, and carrying out the masonry of face wall only up to the level of that already executed, and completing the earthen embankment with a front slope of 3 to 1, 8 ft. width at top, and rear slope 2 to 1, taken from the earth bank, which has already been thrown up, and which is far in excess of actual requirements. This it is estimated would not cost more than Rs. 25,000. The Consulting Engineer agreed with this proposal.

(See Note by Consulting Engineer for Irrigation—Appendix D).

42. The Baldah Nullah diversion should not be carried out, at any rate at present. If carried out, the Consulting Engineer who inspected the site considers an earthen bund across the nullahs which join below the cut is all that is required. The channel as excavated is not nearly broad enough, but as the cutting is throughout through soft rock and would be expensive, the earth dam should be made high enough to form a tank capable of storing *all* the water available on the hilly catchment area of 4½ square miles, or say 73 m. c.ft., and with sluice gates at the head of the cut this would be let down to the Sirohi Tank as required.

(See Note by Consulting Engineer for Irrigation—Appendix E.)

Danta Project.

43. At Danta (Site No. 5), about 7 miles south of Sirohi, there is a site for a Storage Reservoir where the Khemeri debouches from the hills. The river has a drainage area at this point of 15⅓ square miles, and as the catchment area is all hilly, we may safely assume that 10 per cent. of the average rainfall is available for storage, or 84 m. c.ft. Surveys were made, and the tank is designed to store 60 m. c.ft., the weir level being 30 feet above river bed; this would have to be raised another 2 feet to hold the whole of the anticipated run off.

The dam which would be constructed across the gap between the hills through which the river passes would be 1,073 r.ft. in length, of earth, with a core-wall of masonry in lime, and concrete foundations taken down to the rock, which is 20 feet below the river bed. The front slope would be 3 to 1 pitched and rear slope 2 to 1, crest of dam 11½ feet wide, including core-wall, and 37 feet above nullah bed. The weir, which would be 7 feet below crest of dam and 215 feet in length, to pass the maximum discharge of 5,891 c.ft. per second, with a 4 feet head, would be cut through a ridge between the hills on the right of the dam. The estimated cost works out to Rs. 74,750, which includes two miles of canal, to reach the good culturable land lying idle near Makrora village.

The water stored would be sufficient to irrigate 6,000 acres, and if all this land could be taken up, and allowing Rs. 4 per acre, Rs. 2,400 would be the possible revenue, or about 3¼ per cent. on capital cost.

It is an expensive project, the cost of water stored working out to 800 c.ft. per rupee, and the Consulting Engineer who inspected the site does not, in consequence, recommend its execution.

(See Note by Consulting Engineer for Irrigation—Appendix F).

Site at Junction of Krishmauti and Khemeri Rivers.

44. The only other possible site for storage on these rivers is at the junction of the Krishmauti and Khemeri, about 8 miles below Sirohi (Site No. 6).

On the left bank of the Khemeri there is a low range of hills, which would form a natural dam, and the dam itself would have to be extended across on to the right bank, where there is a great plain of good culturable land lying waste for want of water. The catchment area at the site is 60 square miles. The dam would be over a mile in length, and the weir level about 20 ft. above river bed to store sufficient water to irrigate the land required. The construction of a weir across the river, with a cut from the river to bring the water on to the surface where another dam would be constructed to store the same, as proposed for Chuli (para. 28), would probably be a cheaper way of making use of the water.

The site was shown to the Consulting Engineer, and though either project is feasible, it was considered that they would be beyond the present requirements and resources of the Sirohi State, and in consequence only trial surveys will be made to ascertain the approximate cost of carrying out either proposal, and to collect sufficient data to decide whether it is worth while preparing detailed plans and estimates.

(See Note by the Consulting Engineer for Irrigation—Appendix G).

45. On the Pardi Nullah there is a site for a small reservoir at Bilangri (Site No. 7), which has been surveyed, but the estimate has not yet been worked out in detail. **Bilangri Project.**

Catchment area ... ... 10 square miles.
Water available for storage at 10 per cent.
of average rainfall of 23½ inches = 54·8 m. c ft.
Capacity of proposed tank ... ... = 55 m.c.ft.
Approximate estimated cost ... ... Rs. 50,000.
Approximate estimated revenue = 510 acres at Rs. 4 per acre = Rs. 2,040, or 4 per cent. profit on cost.

The dam will be of earth, with a masonry core-wall 2,250 r.ft. in length, front slope 3 to 1, rear slope 2 to 1, top width, including core-wall, 11½ feet, and will connect a ridge of low hills on either side the nullah, forming a natural bund.

The maximum height of dam above nullah bed will be 31 feet, and 6 feet above weir level.

The weir, which will be 255 r.ft. in length, will pass the maximum flood discharge of 4,620 c.ft. per second with a 3 feet head, and will be in a gap in the ridge of hills, 150 r.ft. from end of dam, on the left bank of the nullah.

The project will be worked out and estimated in detail, for execution, whenever the Durbar may wish.

46. Beyond the junction of the Pardi Nullah with the Krishnauti nothing more can, it is thought, be done with the river itself, but on the tributaries forming part of this drainage area the following were noted:—

(1) At Doodia (Site No. 8) a small tank could easily be formed by building a masonry wall about 25 feet in length, between two hills, through which a nullah flows close to, and north of the village. **Doodia Project.**

(2) At Varal (Site No. 9) is an old tank, with escape on a small nullah. The weir is broken and should be built up, but the dam itself could be extended to take in the Varal main nullah, and the tank formed would have a catchment area of 6 square miles. **Varal Project.**

(3) At Kalandari (Site No. 10) a good tank has been constructed, but is not used for irrigation, and is supplied only by a small nullah, another nullah with a catchment area of 1½ square miles passing just at the toe of the dam.

The dam should be extended to take in this, and a sluice built, and the land below which is lying idle could be irrigated.

These are small projects, and surveys will be made if the Durbar wishes, but it is thought they could be carried out locally without help and assistance.

Kachmauli River.

47. **KACHMAULI RIVER** (Drainage area No. 4.)—This river has only a course of 11 miles in the Sirohi State, after which it passes into Marwar, and finds its way into the Luni. There is no site for storage on this catchment, but the small tank at Motagaun might be enlarged and improved to take in another nullah, which now passes just outside the dam. This would add another mile of catchment. (Site N° 11)

Motagaun Tank extension.

Kopalgunga River.

48. **KOPALGUNGA RIVER** (Drainage area No. 5.)—This river rises in the Sunwara Plateau, and after a north-west course of 24 miles flows into the Sukri, about 4 miles beyond the Sirohi border.

Poidra Project.

49. There is a good site for a Storage Reservoir at Poidra (Site No. 12), which has been surveyed, but the estimate has not yet been worked out in detail. The following are the details of the project:—

Catchment area	...	... 19¾ square miles.
Water available for storage	...	... 108 m. c. ft.
Capacity of proposed tank	...	... 99 „
Approximate estimated cost	...	.. Rs. 61,500.
Estimated Revenue, if all water stored is used, 990 acres @ Rs. 4		... Rs. 3,960.

The dam will be 2,600 r.ft. in length, and will be of earthwork, 12 ft. wide at crest, which is 37 ft. above nullah bed, front slope 3 to 1, rear slope 2 to 1; a core-wall is provided for 600 r.ft. where the dam crosses the river, and the weir, which is 280 r.ft. in length, to pass the maximum flood discharge with a 4 ft. head, is on the north end near Poidra village, where there is good rock. The basin is good, and rock is close to the surface in the river bed, but on re-inspection of the project I am not prepared to recommend its execution, for the following reasons:—

(*a*) About 10 wells, with the land they irrigate, would be submerged.

(*b*) Water never runs dry in these wells, or in the river itself.

(*c*) There are wells below, close to the river bank, which appear to irrigate all the land required by the existing cultivators; in fact I noticed several of the wells were lying unused: and though there is land lying idle, which would be commanded by the tank, I doubt if there are sufficient cultivators to take it up.

50. If anything is required here, there is an excellent rock site for a weir just below the temple and site proposed for the tank itself, where a weir could easily and cheaply be built to hold up water to benefit the wells, and from which water could be led off, if necessary, to cultivate the land near the river below; the weir would be 700 r.ft. in length.

Sukli River.

51. **SUKLI RIVER** (Drainage area No. 6).—There are two branches to this river. The westerly rises in the hills near Dantrai, and after a south-easterly course of 14 miles joins the eastern branch between Réodhar and Mandar. I inspected the river from its head, between the hills at Jirawal, down to its junction with the eastern branch. The only possible site for storage, or for a high bund with a cut leading from it was a mile below Basan (Site No. 13). Here there is a long pool of water which I am told flows all the year round. At the time of my inspection (24th November 1903) there was 3 ft. of water in the river, but I do not think any project for making use of the water could be carried out here the expense of which would not be prohibitive, as the river runs in deep banks and the land on either side is sandy and broken by cross drainage; nor does so large a project seem necessary here, as the tributary nullahs all have water in them also for a great part of the year, in normal years, from which the land by the sides is irrigated either direct or by lift; and at Godwara, near Madar, a sand bund is constructed each year across the nullah, quite one mile above the village land, which is irrigated from it by a "saran." This system might no doubt be extended on the tributaries.

This portion of the State appears fairly well protected naturally, and I am informed did not suffer in the famine as severely as the rest.

The eastern branch rises in the Sanwara hills and the north-west slopes of Mount Abu, and flows for about 30 miles through the State. After Anadra it widens out into a very broad river with high banks, and is dry for the greater portion of its course soon after the rains.

Sites for Weirs at Sirori and Panera

There are good rocky crossings suitable for weirs to hold up water near its source at Sirori and Panera (Site No. 14), but I do not think at any other point anything else is feasible

The Panera site would be an excellent one for a Storage Reservoir, but all the well land of the village would be submerged, and instead a weir should be built if it is only to benefit the wells, as it could be cheaply constructed. Good rock foundations already exist, and it would only be 200 ft. in length.

Western Banas River

52. **WESTERN BANAS** (Drainage area No. 7).—This is the principal river in the State. Rising in the eastern slope of the hills behind Sirohi, it flows for 10 miles in an easterly direction till Jharol is reached, near Pindwara, and then turns round to the south-west and continues its course for another 38 miles through the valley between the Abu hills and the Aravallis, and then passes into Palanpur territory.

Seori project.

53. Starting at its source on the north branch at Seori village (Site No. 15) there is a very good site for a Storage Reservoir, which was inspected by the Consulting Engineer, and met with his approval. It is now being surveyed and will be worked out in detail.

Seori village is built just below a rocky hill on the left bank of the nullah, and there is a continuous line of sheet rock, cropping up in the form of large boulders across the nullah, and for about 500 ft. on the right bank; and on this line the dam will be constructed, either of masonry throughout, or a face-wall of masonry with earth backing, continued till high ground is reached on either side by an earthen dam. The bed is rocky, and no well land will be submerged; only a little culturable land near a small hamlet, consisting of a few huts which has lately been started above Seori, and which can easily be removed below the dam, where there is plenty of good land lying idle for want of water stretching right down to the railway line.

The catchment area is 9 square miles, but quite 20 per cent. of the average rainfall of 23½ inches should be available for storage, or 99 m.c.ft., sufficient to irrigate 990 acres.

(See Note by Consulting Engineer for Irrigation—Appendix H).

Baldah Nullah and Pindwara Tank.

54. The Baldah Nullah (para. 37 and Appendix E.), which it is proposed to divert into the Sirohi Tank, is at the head of the Sunwara Branch, and the Jubilee Tank at Pindwara (para. 18 and Appendix A.) has also been formed on one of the sources of the Banas.

Sites at Jhanapur and Pholera.

55. On the nullah which rises in the hills west of Sonwara, there is a good site (Site No. 17) near Jhanapur village for a weir, from which a supply cut can be taken to the existing tanks at Kojra, Dhandpura, and Peshwa, which should be enlarged and strengthened and provided with proper sluices.

The water in the wells belonging to these villages is scanty, and any increase to the storage capacity of these tanks would be valuable, as there is plently of spare land at Dhandpura and Peshwa to be irrigated, and the wells would also be benefited.

Surveys for this are being carried out and the project will be worked out in detail.

It was at first thought that the Peshwa and Dhandpura Tanks could be supplied from a weir across the nullah at Pholera (Site No. 17A), as these in also a good site here, but levels show it is too low for the purpose.

A storage tank could be constructed at this site, but it is not recommended, as it would be an expensive project; the Dam would be a long one, over 4,000 r.ft., and there is not sufficient good land commanded to make the project pay.

Moreover, if later it was found advisable, a good portion of this land could be irrigated from the enlarged Peshwa tank.

Mandwara project.

56. On the next branch on the right bank there is a site (Site No. 18) for a Storage Reservior above Mandwara village, at the point where there is a good rock crossing to the river.

The land submerged is grass land, and below and near Mandwara, which is deficient in wells, there is good land available for irrigation. The nullah has a catchment area of 10 square miles, mostly hilly, so that the tank should be made capable of storing 20 per cent. of the average rainfall, or 110 m.c.ft., sufficient for 1,100 acres. Surveys for this project are being prepared.

57. Next, on the left bank near Rohera village, surveys have been made for the Storage Reservoir at Bhula (Site No. 19), which was commenced during the famine (para. 19). Seven nullahs join just above the site and pass through a gap between two hills, which it is proposed to close by constructing a dam 1,400 ft. long, with a maximum height of 49 ft. above the bed of the nullah. They drain an area of 35 square miles, all hilly, so 20 per cent. of rainfall may be estimated as available for storage, or 380 m.c.ft., and the tank has been designed to contain 320 m.c.ft. The dam will be of earth with a core-wall, front slope 3 to 1 pitched, rear slope 2 to 1. As no rock for foundations can be discovered, the foundations will be taken down 20 ft. below bed, or half the depth of water against the dam. Bhula Project near Rohera.

There is rock on the hill on the right bank where it was proposed to construct the weir 40 ft. above river bed, but as the fall for the overflow would be great, a water cushion would have to be constructed.

As suggested by the Consulting Engineer, who inspected the site, it is now hoped that it will be possible to make the weir away from the dam in a gap between the hills on the north side, but this gap is 67 ft. above bed of nullah, necessitating 27 ft. depth of rock cutting at top of ridge, or probably about 4,52,000 c.ft. in all to clear away the 310 ft. length of weir required, and this would cost Rs. 16,950 at Rs. 3-12 per 100 c.ft. A good portion of the rock excavated could be used in the core-wall masonry, and in any case it will probably be found cheaper than the high masonry weir, and will be a far better arrangement. Surveys are being taken, which will allow an exact estimate of the cutting required and cost to be made. The basin is a good one, but there are said to be 10 wells in the bed which will be submerged. The approximate cost of the project is Rs. 1,45,000, or 2,200 c.ft. of water per rupee; and if there was sufficient land below there should be water enough to irrigate 3,200 acres, but the area of land which is culturable and not already irrigated by wells, though not accurately known, as no revenue surveys have been made in the Sirohi State, is certainly limited. Surveys will now be taken to settle this, and it can then be definitely fixed whether the project is worth carrying out. In framing our estimate of cost the expenditure already incurred during the famine (para. 19) should be neglected, but the 5,900 c.ft. ballast then collected and still lying at site may be valued at Rs. 3 per 100 or Rs. 1,770, and credited, as it can be used in the concrete foundations.

(See Note by Consulting Engineer for Irrigation—Appendix I).

58. About 4 miles north-west of Rohera there is another site at Waloria (Site No. 20), which was inspected by the Consulting Engineer, but he did not consider it worth while to go to the expense of making surveys. Site at Waloria.

At the site selected three nullahs meet, which drain an area of 38 square miles, all hilly, so that 415 m. c.ft. will certainly be available for storage. The dam would be 1,000 ft. long, starting from the range of hills on the right bank across to a detached hill on the left, and the weir would

have to be in the gap of 550 r.ft. from this hill across to another connected with the range of hills which runs parallel to the left bank, unless levels showed it would be possible to make use of a ridge forming the watershed to the west of the range on the right bank.

The land in the bed is high and slopes up rapidly, so that to store much water a high dam would be necessary, and a core-wall or face-wall would have to be provided. The culturable land below is limited and at some distance from the site of Dam, and a great part is already irrigated by wells; so that although there is plenty of water available for storage, it would not, it is thought, be worth while to carry out so large and expensive a project.

(See Note by Consulting Engineer for Irrigation—Appendix J).

Kotra Project

59. Opposite Rohera, on the right bank near Kotra, a large nullah leaves the Abu hill, which starts from the Hetamji valley, near Abu itself, and drains an area of 26 square miles. This nullah flows as a mountain torrent during the rains, and continues flowing till March in years of good rainfall. In 1898 the Resident, Western Rajputana States, suggested the possibility of a Storage Reservoir being constructed at the point where this stream debouches from the hill, and the Executive Engineer, Mount Abu, inspected two possible sites (Site No. 21). The first is where the nullah leaves the hill and divides into two streams; the valley is some 700 ft. wide, and the bed for the whole width is composed of boulders of all sizes wedged together in sand.

The Executive Engineer condemned this site, and rightly, as it would be a most expensive project. The dam would be 800 ft. in length; deep excavation for foundations through the heavy boulders would have to be made, and the dam would have to be of masonry in the form of a weir, as there is no site for the escape elsewhere.

The second site is about 2,000 ft. higher up, where there is a single well-defined stream which passes over a bed of sheet rock, about 80 ft. wide, under a cliff of large boulder rock on the left bank, there being a gap of about 300 ft. between this and the hill on the right bank, and the bed after the 80 ft. of sheet rock consists of large boulders.

This site was also condemned by the Executive Engineer, as a very high dam would have to be constructed to store any water, as the valley slopes up rapidly above, and foundations would be very expensive. The dam would have to be of masonry as a weir, as there is no means of providing for the escape elsewhere, and as the fall for the overflow, with the high dam required, would be very great, a second wall to form a water cushion would be necessary. The cliff of boulders is also not reliable, and would probably leak; and the cost of the Irrigation ducts would be great, owing to the distance from the land to be irrigated.

If anything is done here, and the water should not be lost, I think it should be in the form of a rapid, constructed at the point below the first site, where the villagers at present make "kutcha" bunds after the rains to hold up a certain amount of water, which is run off in "sarans" to irrigate land below. This principle should be carried out, I think, on

an improved and larger scale, and as suggested by the Consulting Engineer for Chuli (para. 28).

I would construct a weir with a masonry core-wall, 3 ft. wide at top, as a backbone, with foundations taken down about six feet below bed if rock is not found.

The weir should have a front slope of boulders of 3 to 1, and a rear slope of the same, 12 to 1, with a line of huge blocks of concrete (boulders and lime constructed at site) imbedded in the nullah at the toe of the rear slope to prevent it shifting. There would be no storage, but the whole of the water flowing down the nullah after the rains and up to the end of March should be made use of, instead of only a portion. A weir as proposed, 700 ft. long and 15 ft. above bed of river, would cost approximately Rs. 4,500.

If this proved a success, the system could also be carried out on the two nullahs which come down from the hill north of Kotra, provided land and cultivators are available.

Kui Project.

60. The next possible site for a Storage Reservoir is at Kui, on the left bank (Site No. 22), just opposite Abu Road.

Surveys were made for this some years ago, by the Executive Engineer, Mount Abu, but cannot now be traced, and the tank was never constructed; the objections to the project are its proximity to Abu Road and the Railway, and that the Durbar have lately constructed, or given advances for the construction of 10 wells on the land commanded.

The nullah to be bunded has a catchment area of 5 square miles, and two dams would be required, the main dam across the gap between the hills through which the nullah passes, and the other on the south side of the hill to prevent overflow through another gap between the hills.

Trial Surveys will be made to enable an approximate estimate of cost to be prepared to see if the project is worth taking up and working out in detail.

Girwar Project.

61. Passing again to the right bank there is a site for a Storage Reservoir at Girwar (Site No. 24), at the foot of the Abu Hill, a little south of the existing Chandela Tank (Site No. 23), where one of the Abu streams passes out of the hills. The project has been surveyed, but the estimate has not yet been worked out in detail.

The drainage area is 6 square miles, forming the slopes of the Abu Hill, and we may safely assume that the average rainfall on this catchment is 30 inches (64 inches is the average rainfall at the top of the hill), and that 20 per cent. is available for storage, or 84 m. c.ft. With a weir 30 ft. above the nullah bed, the tank will have a storage of 85 m. c.ft., so this may be accepted. The dam will have a core-wall, with a front slope of earth, 3 to 1, pitched, and rear slope 2 to 1, and the crest of dam will be 7 ft. above weir level.

The dam itself will be in two lengths, 1,100 ft. in length across the gap between the hills, through which the main nullah flows on the

south, and 920 r.ft., ending with the weir 200 r.ft. in length, or 1,120 r.ft. in all, to close the north gap.

The weir will pass the maximum discharge of 3,160 c.ft. per second, with a 4 ft. head. The irrigation channel will have to be taken for a short distance through the hills before reaching the land to be irrigated, of which there is plenty.

There will be sufficient water to irrigate 800 acres, and allowing Rs. 4 per acre, if all is taken up, the revenue may be estimated at Rs. 3,200 per annum, or $4\frac{1}{4}$ per cent. on the cost, estimated approximately at Rs. 76,500.

This part of the State is inhabited by Bhils and Grassias, and if the project is not carried out at once, it would be a useful work should another famine occur.

Sevalia and Sukri Nullahs

62. Two large tributaries, the Sevalia Nullah and Sukri Nullah, flow into the left bank of the Banas close together, about $2\frac{1}{2}$ miles from the south border, and though they drain over 100 square miles of the Arravelli Hills, they debouch from these hills too close to the Banas and the border of the State for any practical use.

Western Banas

63. With the Banas itself, nothing, it is thought, can be done. There are no sites on it for storage, and though rocky crossings are found suitable for weirs, the valley is too contracted and broken by cross drainage, the culturable land too limited, and cultivators deficient in number, to make large and costly projects of the kind, with so large a river to deal with, worth consideration.

Summary of result of Investigation.

64. The result of the investigation in Sirohi may be summed up as follows :—

1. *Storage Reservoirs.*—

   (*a*) The Ora and Seori Tank Projects might be taken up with advantage at once, and the Girwar Project is also recommended.

   (*b*) The new Sirohi Tank should be completed, purely as an addition to the water-supply of the city.

2. *Weirs with cuts to supply existing or new Storage Reservoirs.*—

   (*a*) The Rarbor Project should be taken up without delay.

   (*b*) The system proposed at Rarbor on a large scale should be adopted on a smaller scale, to start with, on many of the smaller nullahs, the water of which flows in the rains and at present passes away out of the State. This system should be gradually extended. (See para. 31).

   (*c*) The Jhanapur weir and feeder to the Kojra, Dhandpura and Peshwa tanks should be carried out. (See para. 55).

   (*d*) The existing tanks at Kalandri and Motagaun (see paras. 46, 47) should be enlarged to take in the additional catchment areas.

3. *Streams which flow after the Rains.*—

The proposal for a weir at Kotra (para. 59) should be carried out provided, of course, there are sufficient land and cultivators to warrant its construction. This applies to all the Irrigation Projects suggested.

4. *Wells.*—These are the main sources of irrigation in the State, and the form most suitable for this kind of country and its requirements, and protection from famine is more likely to be obtained through them. (See para. 17).

State assistance should, therefore, be given to deepen and improve wells where necessary, to construct new wells wherever there is a demand, and to bring into use wells lying disused.

F. ST. G. MANNERS-SMITH,
SUPERINTENDING ENGINEER,
Protective Irrigation Works, Rajputana.

NOTE BY THE CONSULTING ENGINEER

FOR

IRRIGATION IN RAJPUTANA.

Note by the Consulting Engineer for Irrigation in Rajputana.

1. The Superintending Engineer in his Note on the Sirohi State, has described the physical features of the country, and given much useful information. The Consulting Engineer in November made a short tour with him through the Sirohi State, and inspected all the places on which his opinion was desired. His Notes on each of the places visited are attached.

It is unnecessary, therefore, to do more now than to point to some of the conclusions which suggest themselves from the facts alluded to in these Notes.

2. Owing to the extensive ranges of hills in the middle of the State, *the ground slopes rapidly; from this, and the rocky nature of the greater* part of the ground, it is evident that of the rain that falls, a *large percentage* must run off; also that it must pass *quickly* away.

Almost the whole of this water is lost to the State, while there are large tracts of land lying waste where water is required. Only one-ninth of the State is said to be under cultivation.

3. The Maharao himself seems ready to do all he can in the way of irrigation, as evidenced by the large sums he has spent in the last few years in attempts to store water, and in the intelligent interest he showed in the subject. It is a great thing to find a Chief so disposed. From what has been explained to him, H. H. the Maharao seems to understand and to appreciate our efforts, as a proof of the interest taken by the Imperial Government in this important subject, and its readiness to do all that is possible to help his State.

4. It is evident from the Superintending Engineer's Note that he has done his best to investigate the possibilities of Irrigation in this State. Considering the short time available he could not have done more. It is possible other places may be found hereafter, in addition to those alluded to in these Notes; still, enough has been placed on record to make a good beginning, and suggestions have been made which, it is hoped, will show what may be done and how to do it.

5. The decrease in population noted in para. 8 shows the need there is for protection against famine. Much can be done,—

(1) To store water for cultivation, and

(2) To preserve fodder in good years to feed the cattle in bad years.

(See para. 22 of the Superintending Engineer's Note.)

6. If the Durbar have an interest of $\frac{1}{4}$ to $\frac{3}{4}$ of the produce in Jagir villages (para. 9) it ought to make it less difficult for the Durbar to deal with cases in which Jagirdars are concerned. At all events the Durbar, by example and encouragement, can do much to ensure co-operation.

7. Nearly all the irrigation in the State at present is from wells. The value and importance of wells were proved in the last famine, and cannot be over-rated. I fully endorse the suggestions made by the Superintending Engineer in paras. 13-17 and in para. 64 as deserving of attention.

8. Large Storage Reservoirs, when successfully carried out, are of great benefit to any State, but it is well to remember that the resources of the Sirohi State are limited; that the villages are few and far between; that at present it is doubtful if there are people ready to cultivate much more land than at present is cultivated; that some storage tanks which have been made in late years have not been a success; and that there is uncertainty sometimes whether water if stored will not disappear in the soil. Large works, moreover, take a long time to carry out, and a still longer time before the benefits can be fully realised; and if carried out with borrowed money, often add, for a time at least, to the financial burden of the State.

While, therefore, we have endeavoured to find sites for large Storage Reservoirs, and to suggest works of greater scope than the people themselves could initiate, we have felt that all the above points call for consideration and demand caution.

9. At the same time, looking at the map of the State, it will be seen how many nullahs there are, and how they are distributed naturally over the whole State, and that nearly every village is commanded by some nullah on higher ground, and what a large amount of water must annually run to waste. If there are people ready to make use of the water why should not a large portion of it be diverted by weirs or cuts from the nearest nullah on to the waste lands which surround almost every village?

Why should not the water be stored here and there in long shallow earthen bunds, from which, in due season, it might be let out to the fields below, and the beds of these shallow tanks then be cultivated?

Why should any existing tanks in any village remain unfilled, when nullahs near them in the rains flow away to the sea?

10. In paras. 30 and 31 the Superintending Engineer has stated clearly that the procedure I suggest should be adopted. It is unnecessary, therefore, to repeat it here, but I would strongly invite attention to this system, as it appears to me to be most suitable to the conditions of this State.

11. For every village wherever the need or possibility exists, projects with estimates should be prepared; levels should be marked and permanent bench marks be put up, so that the work could be started at any time.

12. The only expenditure which need be incurred at present is the Establishment necessary to do this preliminary work.

When projects are not prepared beforehand it often results in wasteful expenditure afterwards.

13. I fully endorse the suggestions made by the Superintending Engineer in para. 64, regarding :—

(1) Storage Reservoirs.

(2) Weirs with cuts to supply existing or new Storage Reservoirs.

(3) Streams which flow after the rains.

(4) Wells.

S. S. JACOB, Col.,

Consulting Engineer for Irrigation, Rajputana.

EXTRACTS FROM INSPECTION NOTES BY THE CONSULTING ENGINEER, MADE DURING A TOUR IN THE SIROHI STATE.

November 1903.

APPENDIX A.

Pindwara.—On the 9th November 1903, inspected the Jubilee Tank, situated about 2 miles east of Pindwara, where two small gaps at the foot of the hills have been bunded up by masonry face-walls backed with earth.

An inscription in a chatri on one of the bunds states that the work was constructed in 1897 by the Maharao of Sirohi to mark his loyalty and devotion to the throne. The reservoir has filled, but in a few weeks all the water disappears. It does not seem to be a place where one would expect to find so much leakage, although there are fissures in the rocky sides here and there. There does not appear to be any fault in the construction, or want of foresight in the work, in making a Storage Reservoir here.

The reservoir is empty at this date (9th November), and there are no signs to indicate where the leakage occurs. If leakage occurs from the rocky sides it might be possible by covering them over with a good bank of earth to stop the leakage, but there is no certainty that it would be of any use. The only thing that seems feasible is to make field embankments or shallow tanks on the land below, and to run the water off quickly after the rains, and fill these before the water has time to disappear.

This might be done where the ground is flat, so that a shallow bank will hold up a good spread of water, which could be run off when desired, and the fields below and the bed be cultivated. One bank might be made as an experiment, and if this answered more might be made.

The Tehsildar of Pindwara stated that a small bank had been made on this principle but it had not been tried. (See para. 18 of Superintending Engineer's Note).

APPENDIX B.

On the 13th November 1903 with the Superintending Engineer (Mr. Manners-Smith) inspected the site of a proposed Storage Reservior on the River Sukri, about a mile above the village of Suli (about 9 miles south of Erinpura).

The river rises in the hilly range south, and the drainage of about 98 square miles would be intercepted at this place; but the valley is somewhat confined, and the width at the site of the proposed bund would be about 4,000 ft. The nullah itself is wide here, and a great portion of any bund here would have to be in the bed of the nullah. The work would be very costly. The Superintending Engineer now thinks it is not advisable to attempt any Storage Reservior here, and I agree with him. (See para. 27 of his Note).

At the same time it seems a pity not to be able to take some advantage of the large quantity of water which every year flows to waste here, and to consider if it is not possible to divert and store it elsewhere.

There is a large tract of waste land lying to the north-west. If the water can be diverted on to this land and stored in long shallow bunds and made use of afterwards, it ought to be a benefit to the State. An attempt to divert the water appears to have been made some years ago, as the remains of an old canal exist on the left bank.

It is a clearly-defined channel about 2,500 ft. long, 25 feet wide, and in places 6 or 7 ft. deep, and comes out on the natural surface of the ground.

It is said a *kutcha* bund was made across the nullah to divert the water to it, with the object of benefiting the wells near the village of Bagin on the west, but this bund was washed away and the attempt failed.

The floods are stated not to last long, and hence the river is named the Sukri, but the hills are so near and the ground so much of it steep and rocky, that the floods when they do come are sure to be sudden and strong, if they do not last long.

The levels which have been taken show that the waste land to the north can be easily commanded—it is only a question of the best way to divert the water. The canal will not be able to take off more than a fraction of the floods, even if made 50 ft. wide; the rest will have to be passed off safely by a weir of some kind.

The different ways of doing this are :—

(1) By a single triangular spur or groin of massive rubble or concrete blocks projecting a short distance into the river, to divert a portion of the river flood only, and to allow a free course to the rest.

(2) By a large earthen bund across the stream and a permanent pucca weir at one side.

(3) By a needle weir.

(4) By a masonry weir across the river with water cushion or apron of massive blocks of random rubble masonry.

The last (4) appears to be the most suitable method under the circumstances here.

The Superintending Engineer has given orders for the necessary levels and surveys to be taken to enable estimates to be prepared.

The head or mouth of the canal is well located behind a rocky hill, which will protect it from danger of being cut into by any flood.

If the work is ever sanctioned it should be all completed in the river before the floods come, or work partly done will be all washed away. (Para. 29 of Note by the Superintending Engineer).

APPENDIX C.

Ora.—On 12th November 1903 inspected the site of a Storage Reservoir proposed by the Superintending Engineer (Mr. Manners-Smith.) The site is a very good one. The bund would have to be about 4,000 ft. long with H. W. L. at 30 ft. deep. There is a low place at the north end where by building up a few feet an efficient escape can be made between two small hills. The drainage of about 80 square miles from hills and hard soil is brought by several nullahs in a fan-shape and unite at this place.

The basin for storage is very good and extensive. There appears to be very little cultivation in the basin, so no damage would occur, and there are several square miles of waste land below which could be irrigated. (For further details see the Report of the Superintending Engineer.)

I agree with the Superintending Engineer that the project appears a good one, and recommend that Plans and Estimate should be prepared. (Para. 33 of Superintending Engineer's Note).

APPENDIX D.

On 11th November 1903 we also inspected the tanks on the south side and near the town of Sirohi.

The smaller one to the north of the three, called Nakilao, consists of a masonry face-wall furnished with ghat steps and backed with earth. There are a few feet of water now in this tank, but it is said not to hold up the water as intended.

The tank to the extreme south, called Kalka Mata is much larger, and has a capacity of about 13 m. c.ft., but the catchment area is said to be only 1½ square miles. The soil is rocky, and the run-off must be considerable.

In between these two tanks a nullah passes, which it is proposed to bund up, and H. H. the Maharao of Sirohi began the work as a relief measure during the recent famine, the object being to increase the water supply for the town, which is deficient.

The total length of the gap is 2,500 ft. The present state of the work, which is now stopped, is that a face-wall of masonry has been built for about 1,200 ft. to a height of 5 ft. above nullah bed. Earth has been thrown up behind this for the full height of the bund and in thickness far more than is necessary, and for nearly the whole length of the proposed bund a trench has also been dug for the remaining length of the face-wall, in some places deeper than is necessary. The work is now stopped.

This new tank will have a drainage area of about 2¼ square miles, and if the Balda Nullah (alluded to in para. 37) is added, it will add 4 square miles. It will be capable of holding 20 m. c.ft.

No proper Plans and Estimates appear to have been prepared before work was begun, and the wells and cultivated land which will be submerged inside have not been taken into consideration. It is stated that Rs. 47,000 have been already spent here during the famine, and about Rs. 10,000 afterwards before work was stopped. The value of the work done according to the ordinary rates taken now comes to about Rs. 14,500.

The first thing Mr. Manners-Smith rightly did was to have Plans and Estimate prepared, to ascertain what it would cost to complete it according to the original design.

The estimated amount for the project *de novo* is Rs. 1,00,763. Deducting the value of the work already done (if taken at existing rates) Rs. 14,522, the amount required to finish it will be Rs. 86,241, exclusive of the Baldah Feeder Cut.

The question is, whether it is not possible to reduce this large amount in some way. He proposes to fill in the foundations already dug, and to complete the masonry face-wall throughout to the present height only; to complete the earthwork everywhere behind it, sloping it back on the water face 3 or 4 to 1, and at present to do nothing more than is necessary. This will cost about Rs. 25,000, and make a saving on the original proposal of about Rs. 61,000.

The masonry face-wall can be carried up hereafter to the full height originally proposed, if funds are available and it is desired. I quite agree with these suggestions of the Superintending Engineer.

It should be remembered that this is not an irrigation work, and cannot be expected to give any pecuniary return. It has been begun by H. H. the Maharao of Sirohi to afford relief to his subjects in time of need, and to increase the supply of water for the people in the town of Sirohi. Our efforts have been merely to try and suggest measures to save unnecessary expenditure. (Paras. 35-42 of Note by the Superintending Engineer).

APPENDIX E.

Baldah Feeder.—On the 10th November 1903, on the way from Pindwara to Sirohi with Mr. Manners-Smith, inspected a cut which had been made during the recent famine near Baldah, about 4 miles east of the town of Sirohi, with the object of diverting a small nullah, which now flows eastward, to the tanks near Sirohi on the west.

The cut is very narrow, only 5 to 10 ft. wide, and in places 8 to 10 ft. deep: the total length is about ¾ mile, and much of it is in rock. The nullah it was intended to divert has not yet been diverted, so the cut at present is of no use.

We examined the ground and selected the best places to put the diverting bunds; two probably will be required; each would be about 300 or 400 ft. long and a few feet only in height, with perhaps a short cut through intervening ground. Until levels have been taken it is not possible to state what the cost would be, but it would be trifling.

There is a good-sized basin to the north, and it will probably be found more economical to make the diverting bunds sufficiently high to allow the water to head back and spread over this basin, than to attempt to increase the size of the channel. Although the cut in its present state could not carry off the flood water of the nullah, if it is possible to store it for a time in the basin, it might be sufficient to empty the basin in a few hours.

Whether the tanks near Sirohi will not fill without this feeder is not certain, so the necessity for this cut is not proved. However, as a good deal of work has been done here already, it seems advisable to have the Plans and Estimate prepared for completing it, so that it can be taken up when the necessity arises. (See para. 42 of Note by Superintending Engineer).

APPENDIX F.

Danta.—On the 11th November 1903, went with Mr. Manners-Smith to see the site of a proposed Storage Reservoir at Danta, about 7 miles south of Sirohi, where a nullah passes through a range of hills.

The width of the gorge is about 1,100 ft.; the drainage area about 15½ square miles of hilly ground. The basin is not as good as it might be, as there is much hilly ground inside it.

The Plans and Estimates have been prepared, from which it appears the quantity of water which would be stored would be only about 60 m. c.ft., and the cost about Rs. 74,750. This means only about 800 c.ft. stored per rupee. I do not therefore recommend this project, but the Plans and Estimates might be placed on record. (See para. 43 of Note by Superintending Engineer).

APPENDIX G.

On the 12th November 1903, with the Superintending Engineer (Mr. Manners-Smith), inspected a site about 6 miles west north-west of Sirohi, between Pardi and Mandwa, at the junction of the Krishmauti and Khemeri Nullahs, where it is suggested a Storage Reservoir might be possible. On the west there is a good rocky range which forms a natural bund on this side ; rock crops out in the nullah bed at both banks, which are low; the basin for storage is very good, and there appears to be any amount of good land below, but the villages appear few and far between. The drainage area, which would be intercepted at this place, would be about 60 square miles. On the east side of the nullah the country is more open, and it will be some distance before the bund will reach high ground. This will naturally make it a large and expensive work.

The Plans and Estimate have not yet been prepared, and I do not feel able to say enough to recommend the project, but it would be worthwhile, I think, to ascertain sufficient data to enable a fair idea to be formed whether it would be worthwhile to incur the cost of preparing detailed Plans and Estimate.

It would be worthwhile, perhaps, to see if it is possible to make a long low bund of earth on the land below, where by diverting the nullah, some of the flood water might be impounded. If the Sirohi Durbar wish this land irrigated and the water can be diverted economically, it might be worthwhile to try this first. (See para. 44 of Note by Superintending Engineer.)

APPENDIX H.

Seori.—On the 10th November 1903, on the way from Pindwara to Sirohi, inspected the site proposed for a small Storage Reservoir, with Mr. Manners-Smith, at Seori, about 3 miles north of Jharol. The catchment area is about 9 sq. miles.

A chain of trap rock crops out advantageously for a bund line, there appears to be very little cultivation in the bed, the basin is a good one for storage, the rock affords a safe escape for any surplus water, and there is good land below which could be irrigated. The Tehsildar of Pindwara, who accompanied us, said there were 15 wells now below, but that 7 of them were without water, and he spoke hopefully of the proposal to store water here.

The site appears to me a good one, and I recommend Plans and Estimate should be prepared. I would suggest every advantage being taken of the line of rock to utilize it as much as possible in the formation of the bund, which need not be in a straight line, but may follow the line of rock for some distance. (Para. 53 of Superintending Engineer's Note.)

APPENDIX I.

1. 7th November 1903, inspected the site for the proposed Storage Reservoir at Bhula, near Rohera, with the Superintending Engineer, Mr. Manners-Smith. (See his Report, para. 56).

2. The site is about 3 miles south-east of the village of Rohera, where some nullahs from the range of hills on the east unite and pass through a low range of hills.

3. Some work was begun here in the last famine, apparently without proper Plans and Estimates having been prepared beforehand.

4. It is stated some Rs. 30,000 were spent. All that exists now to show for it is a deep trench, which was dug for the foundations, and some 5,9000c.ft. of broken stone stacked at the site for concrete. At the north end some concrete has been consolidated and some bench marks have been erected.

The total value of the work if estimated now would probably be about Rs. 4,000 or so.

5. The drainage area is stated to be about 35 square miles ; 20 per cent. of the average rainfall has been taken as the probable amount available for storage, and considering the nature of the catchment this seems to be a fair allowance.

6. The length of the proposed dam would be about 1,400 ft., including a length of 310 ft. at the north end, where it is proposed to make a masonry dam to serve as a waste weir, partly cut into the hill-side.

7. Surveys and plans have now been prepared for the dam, the escape, and the sluices, and the estimate amounts to Rs. 14,5000.

The surveys for the canals north and south have been made for about 3 miles. All the data ascertained are alluded to in the Report by the Superintending Engineer, and need not therefore be repeated here.

8. There is some cultivated land and a few wells inside. Below the site there are 80 wells and a good deal of cultivated land, and some uncultivated ground.

9. Before, however, a fair opinion can be given as to the advisability of carrying out this work, or whether it is likely to repay a fair return, it is necessary to know—

(*a*) The area and value of the land which will be submerged.

(*b*) The area of the land commanded ; how much of this is already cultivated, and how much is watered by wells.

Surveys will now be taken to ascertain the information required, and whether the project is worth carrying out.

10. The disadvantages are:—

(1) The unsatisfactory nature of the soil at the site of the bund, necessitating a deep masonry core-wall and great expense.

(2) The difficulty of getting a good escape. On the plans it is proposed to have a masonry wall as an escape at the north end, in some parts 40 to 45 feet high. The rock here does not appear very good, and I should hesitate to allow a fall of such a height, and a proper water cushion would add much to the cost. It would be better to try and cut down any low saddle in the range to the north to form an escape, if it can be done at a reasonable cost, even if it necessitated raising the H. W. L.

(3) No return could be expected from the land already under well cultivation below the bund.

(4) There are already 80 wells with Persian wheels irrigating most of the land below the site, so that the need for any large irrigation work here does not exist, although it does seem a pity some use cannot be made of the expenditure which has been already incurred.

11. Under the above circumstances I am not disposed to recommend the Sirohi Durbar to undertake this work, at present at all events. It seems advisable, however, to ascertain the information still required, and to complete the surveys, plans and estimate, as time and money have been expended in preparing them, and it will be well, therefore to make them complete and to place them on record, in case they may be required for reference hereafter. (See para. 57 of Note by Superintending Engineer).

APPENDIX J.

1. *Waloria.*—On the 8th November 1903 I went with the Superintending Engineer to inspect a site which had been suggested for a Storage Reservoir near Waloria, about five miles north-east of Rohira. Waloria appears to be not a village, but a colony of isolated Bhil huts, few and far between.

2. The proposed site for the dam is where three nullahs from the adjacent hills unite. The main gorge is about 1,000 ft. across, and an open space on the left bank, about 600 feet wide, would also have to be bunded up.

3. The catchment area is said to be about 38 square miles in the hilly ranges to the north and east.

4. We also inspected the eastern nullah for some distance above its junction with the main nullah, to see the remains of an old bund which the Bhils said once existed here. We saw a small part of a wall, but it is difficult to say if any bund was ever made here. There is no basin for storage above it, and it is not a suitable place for storing water.

5. If a bund is ever to be made here there will be difficulty about finding any natural escape at H. W. L.—perhaps one might be found to the west at the lowest part of the hills. For further particulars see Note by the Superintending Engineer, para. 58

6. The site here appears to have the following disadvantages—

(1) The basin inside is not good; it consists of a good deal of high ground with the exception of about half a square mile on the west.

(2) The width of the two openings which would have to be bunded up would make the expense great.

(3) There would be difficulty and great expense in getting any canal away to any land requiring water.

(4) There is only one village below, between it and Rohira, *viz.*, Wasa.

(5) Owing to scanty population there is doubt as to the water, even if it was stored, being made good use of.

Under the above circumstances I agree with the Superintending Engineer, that it is not worthwhile to go to the expense of making Surveys or Plans and Estimates.